CLAIMS

1. A method of determining hysteresis of a process device in a process, the method comprising

collecting sample pairs of signals representing a control input and a process output of a process device,

calculating the hysteresis of the process device on the basis of the collected sample pairs,

characterized by

each collected sample pair comprising an average control input and an average output for a predetermined collection period,

screening (53) the sample pairs suitable for further processing at least according to the magnitude and direction of the relative change of the average control input of each sample pair,

grouping (53) the sample pairs into a first and a second group at least according to the direction of the relative change of the average control input of each sample pair,

calculating (54) a first and a second control/output characteristic curve by means of the screened sample pairs of the first and the second group, respectively,

determining the hysteresis of the process device as a distance between the first and the second characteristic curve at least at one point.

2. A method according to claim 1, **characterized** in that the signal representing the process output comprises one of the following: a measured process variable (y), or a set point (r) of a process variable in process control.

3. A method according to claim 1 or 2, **characterized** in that the screening (53) comprises

calculating the change of average control input for each sample pair in relation to the average control input of the previous sample pair and the direction of the change,

if the calculated change is smaller and has occurred in the same direction as the change calculated for the control input of the previous sample pair, the sample pair is selected for further processing; otherwise the sample pair is rejected.

4. A method according to claim 1, 2 or 3, **characterized** in that the direction of the change is determined by calculating the sign of the change, in which case the sign is positive if the control input is increasing, and negative if the control input is decreasing.

5. A method according to claim 1, 2, 3 or 4, **characterized** in that the screening comprises

selecting a sample pair $u_m(j)$, $y_m(j)$ for the calculation of the characteristic curve if the following two conditions are fulfilled:

$$|\Delta u_m(j)| < |\Delta u_m(j-1)|$$
$$sign(\Delta u_m(j)) = sign(\Delta u_m(j-1))$$

where

$u_m(j)$ is the average control input of sample pair j,

$y_m(j)$ is the average measured output of sample pair j,

j is an integer index,

$\Delta u_m(j) = u_m(j) - u_m(j-1)$

$sign(\Delta u_m)$ calculates the sign of Δu_m.

6. A method according to claim 5, **characterized** in that the sample pairs are grouped into a first and a second group on the basis of the following rule:

if the sign of Δu_m is positive, the sample pair belongs to the first group,

if the sign of Δu_m is negative, the sample pair belongs to the second group.

7. A method according to claim 1, 2, 3 or 4, **characterized** in that the collecting comprises

taking a momentary sample pair (y_s, u_s) from the control input (u_m) and measured output (y_m) at certain intervals, the interval being preferably in the order of one or more seconds,

calculating the average sample pair (u_m, y_m) from the momentary sample pairs (y_s, u_s) taken during the collection period, which is preferably in the order of one or more minutes.

8. A method according to any one of the preceding claims, **characterized** by calculating a reliability value for hysteresis by a function, which includes the following information as parameters

the number Ny1 of average sample pairs (u_m, y_m) belonging to the first, ascending characteristic curve,

the number Ny2 of average sample pairs (u_m, y_m) belonging to the second, descending characteristic curve,

the number Noy1 of sample pairs which belong to the first characteristic curve but are below the second characteristic curve, and

the number Noy2 of sample pairs which belong to the second characteristic curve but are above the first control curve.

9. A method according to claim 8, **characterized** in that

the reliability value L is calculated by function L=max(0.1-Noy1/Ny1-Noy2/Ny2), in which case L may obtain values from 0 to 1, where L=1 is completely reliable and L=0 is completely unreliable.

10. A method according to any one of the preceding claims, **characterized** in that the calculation of each characteristic curve comprises

dividing the control area of the control input into bins $u_0(1)...u_0(n_{bin})$, where $u_0(1)...u_0(n_{bin})$ is the location of the bins on the u-axis representing the control input and bin is the number of bins, in which case the values $y_0(1)...y_0(n_{bin})$ included in the bins represent output values on the y-axis describing the output, and value pairs $u_0(1)/y_0(1),...,u_0(n_{bin})/y_0(n_{bin})$ define a characteristic curve,

updating the values $y_0(1)...y_0(n_{bin})$ of the bins $u_0(1)...u_0(n_{bin})$ by means of the average sample pairs using a predetermined weighting function.

11. A method according to claim 10, **characterized** by

updating two bins b_n, b_{n-1} according to each sample pair, the bins being selected so that the following condition is fulfilled

$$b_n < \frac{u_m - u_{\min}}{u_{\max} - u_{\min}}(n_{bin} - 1) + 1 < b_{n+1}$$

where

u_m is the minute mean value of the control of sample pair j,

y_m is the minute mean value of the measurement of sample pair j,

n = 1...bin,

u_{min} and u_{max} are the minimum and the maximum of the control area, respectively,

updating the values $y_0(b_n)$ and $y_0(b_{n+1})$ of the selected bins b_n, and b_{n-1} as follows

$$y_0(b_n) = \frac{nct(b_b)y_0(b_n) + w_1 y_m}{nct(b_n) + w_1}$$

$$y_0(b_{n+1}) = \frac{nct(b_{n+1})y_0(b_{n+1}) + w_2 y_m}{nct(b_{n+1}) + w_2}$$

where

nct(1)...nct(n_{bin}) each represents the number of updates (control/measurement pairs used) of each bin,

w_n and w_{n+1} are weighting coefficients

$$w_n = 1 - \frac{|u_m - u_{min} - (b_n - 1)u_{st}|}{u_{st}}$$

$$w_{n+1} = 1 - \frac{|u_m - u_{min} - (b_{n+1} - 1)u_{st}|}{u_{st}}$$

u_{st} is the distance between the bins

$$u_{st} = \frac{u_{max} - u_{min}}{n_{bin} - 1}$$

updating the numbers nct(bn) and nct(bn-1) of updates of the selected bins bn and bn-1 as follows

$nct(b_n) = a*nct(b_n) + w_1$

$nct(b_{n+1}) = a*nct(b_{n+1}) + w_2$

where a is constant.

12. A system for determining hysteresis of a process device in a process environment, the system comprising

means for collecting sample pairs of signals representing a control input and a process output of the process device,

characterized in that each collected sample pair comprises an average control input and an average control output for a predetermined collection period, and the system comprises

means (53) for screening sample pairs that are suitable for further processing at least according to the magnitude and direction of the relative change of the average control input of each sample pair,

means (53) for grouping the sample pairs into a first and a second group at least according to the direction of the relative change of the average control input of each sample pair,

means (54) for calculating a first and a second control/output characteristic curve by means of the first and the second screened sample pair (u_m, y_m), respectively,

means (55) for determining the hysteresis of the process device as a distance between the first and the second characteristic curve at least at one point.

13. A system according to claim 12, **characterized** in that the signal representing the process output comprises at least one of the following: a measured process variable (y), or a set point of a process variable (r) in process control.

14. A system according to claim 12 or 13, **characterized** in that the screening means comprise

means (53) for calculating the change of the average control input for each sample pair in relation to the average control input of the previous sample pair and the direction of the change, and for selecting a sample pair for further processing if the calculated change is smaller than the change calculated for the control input of the previous sample pair and has occurred in the same direction; otherwise the sample pair is rejected.

15. A system according to any one of claims 12 to 24, **characterized** in that the system comprises means (55) for calculating a reliability value for hysteresis by a function which includes the following information as parameters

the number Ny1 of average sample pairs (u_m, y_m) belonging to the first, ascending characteristic curve,

the number Ny2 of average sample pairs (u_m, y_m) belonging to the second, descending characteristic curve,

the number Noy1 of sample pairs which belong to the first characteristic curve but are below the second characteristic curve, and

the number Noy2 of sample pairs which belong to the second characteristic curve but are above the first control curve.

16. A system according to claim 14, **characterized** in that

the reliability value L is calculated by function L=max(0.1-Noy1/Ny1-Noy2/Ny2), in which case L may obtain values from 0 to 1, where L=1 is completely reliable and L=0 completely unreliable.

17. A program product which includes a program code, which implements the method steps of a method according to any one of claims 1 to 10 when it is run on a computer or the like.